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09/551272
04/18/00

April 18, 2000

Attorney Docket No.: 04873-065002

Box Patent Application
Commissioner of Patents
Washington, DC 20231

Presented for filing is a new continuation patent application of:

Applicant: YAJUN LI, VLADIMIR GUREVICH, MARK KRICHEVER, EDWARD D. BARKAN, and MIKLOS STERN

Title: ATHERMALIZED PLASTIC LENS

The prior application is assigned of record to Symbol Technologies, Inc., a Delaware corporation, by virtue of an assignment submitted to the Patent and Trademark Office for recording on January 5, 1999 at 9676/0190.

Enclosed are the following papers, including those required to receive a filing date under 37 CFR 1.53(b):

	Pages
Specification	12
Claims	4
Abstract	1
Declaration	3
Drawing(s)	11

Enclosures:

— Preliminary amendment, 3 pages.
— Copy of Petition for Extension of Time filed in parent application.
— Postcard.

CERTIFICATE OF MAILING BY EXPRESS MAIL

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I hereby certify under 37 CFR §1.10 that this correspondence is being deposited with the United States Postal Service as Express Mail Post Office to Addressee with sufficient postage on the date indicated below and is addressed to the Commissioner of Patents, Washington, D.C. 20231.

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MARK CARVEY
Typed or Printed Name of Person Signing Certificate

This application is a continuation (and claims the benefit of priority under 35 USC 120) of U.S. application serial no. 09/109,018, filed July 1, 1998; which is a continuation in part of U.S. application serial no. 08/953,543, filed October 20, 1997; which is a continuation in part of U.S. application serial no. 08/624,935, filed March 22, 1996; which is a continuation in part of U.S. application serial no. 08/173,255, filed December 27, 1993; which is a divisional of U.S. application serial no. 07/860,390, filed March 30, 1992. The disclosure of the prior application is considered part of (and is incorporated by reference in) the disclosure of this application.

Basic filing fee	$690
Total claims in excess of 20 times $18	$126
Independent claims in excess of 3 times $78	$0
Fee for multiple dependent claims	$0
Total filing fee:	$816

A check for the filing fee is enclosed. Please apply any other required fees or any credits to deposit account 06-1050, referencing the attorney docket number shown above.

If this application is found to be incomplete, or if a telephone conference would otherwise be helpful, please call the undersigned at (617) 542-5070.

Kindly acknowledge receipt of this application by returning the enclosed postcard.

Please send all correspondence to:

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Respectfully submitted,

G. Roger Lee
Reg. No. 28,963

Enclosures
GRL/lgg
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Attorney's Docket No.: 04873-065002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Yajun Li et al.   Art Unit :
Serial No. :   Examiner :
Filed : April 18, 2000
Title : ATHERMALIZED PLASTIC LENS

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination, please amend the application as follows:

In the Specification:

At page 1, line 5, following "The present application", please insert --is a continuation of U.S. Application Serial No. 09/109,018, filed July 1, 1998; which--.

In the Claims:

Please cancel claim 16.

1. (Amended) A plastic lens, comprising:

refractive and diffractive optical apparatus configured to produce optothermal changes substantially canceling each other over a predetermined working temperature range to render the plastic lens substantially athermalized over the range, and wherein the lens includes an axicon.

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MARK CARVEY
Typed or Printed Name of Person Signing Certificate

17. (Amended) The lens of claim [16] 1, wherein the axicon includes a polymer.

18. (Amended) The lens of claim [16] 1, wherein the axicon is disposed at a substantially spherical surface of the lens.

19. (Amended) The lens of claim [16] 1, wherein a diffractive optical element and the axicon are disposed at different surfaces of the lens.

20. (Amended) The lens of claim [16] 1, comprising a diffractive optical element that includes at least eight phase levels.

21. (Amended) The lens of claim [16] 1, comprising a diffractive optical element that includes fewer than nine phase levels.

22. (Amended) The lens of claim [16] 1, wherein the axicon is affixed to a surface of the lens.

23. (Amended) The lens of claim [16] 1, wherein the lens has an aspherical surface having the optical properties of a combination of a spherical surface with the axicon.

24. (Amended) The lens of claim [16] 1, wherein the lens includes a doublet.

25. (Amended) The lens of claim [16] 1, wherein the lens includes a Cook triplet anastigmat.

26. (Amended) The lens of claim [16] 1, wherein the lens includes a symmetric double Gaussian.

27. (Amended) The lens of claim [16] 1, wherein the MTF of the lens is higher with the axicon than without the axicon for bar code symbols having spatial wavelengths of 10-20 mils, inclusive.

28. (Amended) The lens of claim [16] 1, wherein the MTF of the lens is at least 0.2 for a 10 mil bar code symbol that is from about 4 to about 16 inches away from the lens.

Respectfully submitted,

Date: 4/18/00

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APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: ATHERMALIZED PLASTIC LENS

APPLICANT: YAJUN LI, VLADIMIR GUREVICH, MARK KRICHEVER, EDWARD D. BARKAN, AND MIKLOS STERN

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Erik Borelli

Erik Borelli

ATHERMALIZED PLASTIC LENS

Cross Reference To Related Applications

The present application is a continuation-in-part of U.S. Application Serial No. 08/953,543, filed October 20, 1997, which is a continuation-in-part of U.S. Application Serial No. 08/624,935, filed March 22, 1996, which is a continuation-in-part of U.S. Application Serial No. 08/173,255, filed December 27, 1993, which is a divisional of U.S. Application Serial No. 07/860,390, filed March 30, 1992. The four aforementioned applications are incorporated by reference herein in their entirety.

Background of the Invention

The invention relates to an athermalized plastic lens.

In a system (e.g., a bar code scanner) that relies on a specific optical property (e.g., a specific focal length) of a lens, changes in temperature that affect the specific optical property of the lens can cause the system to function improperly or inaccurately. For example, if the lens is used in a bar code scanner to focus light reflected from a bar code symbol onto a CCD device that produces an image of the symbol, the produced image may be too out-of-focus to be effectively decoded if the focal length of the lens is affected significantly by a temperature change. Typically, a glass lens is more resistant to temperature changes than a plastic lens having the same shape.

Summary of the Invention

The invention provides an athermalized plastic lens in which optothermal changes are balanced by refractive and diffractive optics, allowing the lens to achieve thermal performance characteristics similar to those of a glass

lens, while being inexpensive, lightweight, and easily shaped. When the lens includes an axicon, the lens provides equipment such as bar code scanners with an extended working range.

Preferred implementations of the invention may include one or more of the following. The lens may include a refractive surface and a diffractive optical element, wherein optothermal changes due to the refractive surface counter optothermal changes due to the diffractive optical element. The optothermal changes may cancel each other and include changes affecting the focal length of the lens. The lens may include polycarbonate. The lens may include acrylic. The lens may include a net positive power. The optothermal expansion coefficient of the refractive optical apparatus may be higher than an optothermal expansion coefficient of the diffractive optical apparatus. The lens may include a diffractive optical element that is substantially smaller than the lens. The first surface of the lens may provide substantially all of the negative power of the lens, and the second surface of the lens may provide substantially all of the positive power of the lens. The surface of the lens may provide substantially all of the negative power of the lens and substantially all of the positive power of the lens. The diffractive optical apparatus may include a diffractive optical element that is substantially spherical in average. The surface of the lens may be substantially flat. The refractive optical apparatus may be divided unevenly between first and second surfaces of the lens. Substantially all of the diffractive optical apparatus may be disposed on one surface of the lens. The diffractive optical apparatus may be divided substantially evenly between first and second surfaces of the lens. The lens may include an axicon. The axicon may include a

polymer. The axicon may be disposed at a substantially spherical surface of the lens. The diffractive optical element and the axicon may be disposed at different surfaces of the lens. The lens may include a diffractive optical element that includes at least eight phase levels. The lens may include a diffractive optical element that includes fewer than nine phase levels. The axicon may be affixed to a surface of the lens. The lens may include an aspherical surface having the optical properties of a combination of a spherical surface with the axicon. The lens may include a doublet. The lens may include a Cook triplet anastigmat. The lens may include a symmetric double Gaussian. The MTF of the lens may be higher with the axicon than without the axicon for bar code symbols having spatial wavelengths of 10-20 mils, inclusive. The MTF of the lens may be at least 0.2 for a 10 mil bar code symbol that is from about 4 to about 16 inches away from the lens.

Other advantages and features will become apparent from the following description and from the claims.

Brief Description of the Drawings

FIG. 1 is an illustration of an embodiment of an athermalized plastic lens having refractive surfaces and diffractive optical elements.

FIGs. 2a and 2b are illustrations of diffractive optical elements that are used in embodiments of the athermalized plastic lens.

FIGs. 3 and 4 illustrations of embodiments of the athermalized plastic lens.

FIG. 5A is a conceptual illustration of an embodiment of the athermalized plastic lens having an axicon.

FIG. 5B is an illustration of the embodiment of FIG. 5A.

FIG. 6 is a flat-profile illustration of a diffractive optical element used in the embodiment of FIGs. 5A-5B.

FIG. 7 is an illustration of another embodiment of the athermalized plastic lens having an axicon.

FIG. 8 is an illustration of bar code scanning using an athermalized plastic lens having an axicon.

FIGs. 9A, 9B, 10A, 10B, 11A, and 11B show MTF curves for athermalized plastic lenses having different axicons.

FIGs. 12 and 13 show MTF curves for different spatial wavelengths used with athermalized plastic lenses having different axicons.

Description of the Preferred Embodiments

FIG. 1 illustrates a lens 10 that is an embodiment of an athermalized plastic hybrid lens ("hybrid lens") that includes refractive and diffractive optics. As described below, by balancing changes in optical properties resulting from temperature-induced expansion or contraction of lens material ("optothermal changes"), the hybrid lens achieves thermal performance characteristics similar to those of a glass lens, while being inexpensive, lightweight, and easy to shape. The balancing is accomplished by special properties of surfaces and elements of the hybrid lens (e.g., spherical refractive surfaces 12, 14 and diffractive optical elements ("DOEs") 16, 18 of lens 10), as described below.

In at least some cases, the optothermal changes resulting from a temperature change produce a focal length difference. For a particular lens, the nature of the relationship between the temperature change and the focal

length difference depends on the characteristics of the lens. In an athermalized lens, the temperature change produces no significant focal length difference, i.e., the focal length of an athermalized lens is not significantly affected by temperature changes.

Lens 10 has a focal length f that includes the following components that are related as described in equation (1) below: a refractive focal length f_r due to the refractive surfaces 12, 14 which have focal lengths f_{r1} and f_{r2}, respectively, and a diffractive focal length f_d due to the DOEs 16, 18 which have focal lengths f_{d1} and f_{d2}, respectively.

(1)

$$1/f = (1/f_{r1} + 1/f_{d1}) + (1/f_{r2} + 1/f_{d2}) = 1/f_r + 1/f_d$$

The refractive surfaces 12, 14 and DOEs 16, 18 have opto-thermal expansion coefficients x_r and x_d, respectively, each of which is a measure of the extent to which the respective focal length (f_r or f_d) is changed per unit of temperature change. Equation (2) below relates changes Δf, Δf_r, and Δf_d in focal lengths f, f_r, and f_d, respectively, to a temperature change ΔT.

(2)

$$\frac{\Delta f}{f} = \frac{f}{f_r}\left(\frac{\Delta f_r}{f_r}\right) + \frac{f}{f_d}\left(\frac{\Delta f_d}{f_d}\right) = \left(\frac{f}{f_r}x_r + \frac{f}{f_d}x_d\right)\Delta T \ ,$$

Since lens 10 is athermalized, focal length change Δf may be taken to be zero, to produce equation (3) which shows that in lens 10 the ratio of expansion coefficient x_r

to focal length f_r is balanced by the ratio of expansion coefficient x_d to focal length f_d.

(3)
$$\frac{x_r}{f_r} = -\frac{x_d}{f_d}$$

Solving equations (1) and (3) simultaneously produces equations (4a) and (4b) which show that the ratio of coefficient x_r to coefficient x_d and its inverse define relationships between focal length f and focal lengths f_r and f_d, respectively.

(4a, 4b)
$$f_r = \left(1 - \frac{x_r}{x_d}\right) f \qquad\qquad f_d = \left(1 - \frac{x_d}{x_r}\right) f$$

For both the refractive surfaces and the DOEs, lens 10 may use polycarbonate material, for which expansion coefficients x_r and x_d have the following values:

(4c)
$$x_r = 246(\times 10^{-6}\,{}^0\mathrm{C}^{-1})$$

(4d)
$$x_d = 131(\times 10^{-6}\,{}^0\mathrm{C}^{-1}) \;.$$

Equations (5a) and (5b) below show that substituting the polycarbonate coefficient values into equations (4a) and (4b) produces a directly proportional relationship between focal length f and focal lengths f_r and f_d, respectively.

(5a)
$$f_r = \left(1 - \frac{246}{131}\right) f = -0.878 f$$

(5b) $$f_d = \left(1 - \frac{131}{246}\right) f = 0.467 f$$

Where lens 10 uses acrylic material, the following values and equations apply.

(5c) $$x_r = 315(\times 10^{-6}\,{}^0\mathrm{C}^{-1})$$

(5d) $$x_d = 129(\times 10^{-6}\,{}^0\mathrm{C}^{-1}) \; .$$

(6a) $$f_r = \left(1 - \frac{315}{129}\right) f = -1.442 f$$

(6b) $$f_d = \left(1 - \frac{129}{315}\right) f = 0.591 f$$

Thus, where the hybrid lens has positive power (i.e., has a focal length greater than zero) and uses a material (e.g., polycarbonate or acrylic) for which refractive surfaces are more sensitive to temperature changes than DOEs (i.e., the value for coefficient x_r is greater than the value for coefficient x_d), the hybrid lens has the general shape of a lens with negative power. However, in such a lens, the positive power of the DOEs overcomes the negative power of the refractive surfaces, to produce a net positive power for the lens. In at least some cases, such a lens can use DOEs that are small relative to the size of the lens.

FIGs. 2A and 2B illustrate lenses 20 and 22 of polycarbonate and acrylic, respectively, which lenses are other embodiments of the hybrid lens and in each of which substantially all of the negative power of the hybrid lens is provided by one of the surfaces 12′ or 12″ and substantially all of the positive power is provided by another of the surfaces 14′ or 14″.

FIG. 3 shows a lens 24 that is another embodiment of the hybrid lens and in which one of the surfaces 12‴ provides not only substantially all of the negative power but also substantially all of the positive power, and the other surface 14‴ provides no significant negative or positive power. As shown in FIG. 3, the one surface may include a DOE that is substantially spherical in average and the other surface may be substantially flat and may be used for aspherical replication.

FIG. 4 shows a lens 26 that is another embodiment of the hybrid lens and in which one substantially spherical surface 12'''' provides less of the refractive power than another substantially spherical surface 14'''', and substantially all of the diffractive power is provided by a surface-relief DOE on the other substantially spherical surface 14''''. Surface 12'''' may have an aspherical surface or replica.

Where the two surfaces of the hybrid lens contribute substantially equally to the diffractive power, a size increase amounting to a factor of four may be achieved for features of the DOEs without a significant loss in resistance to optothermal changes.

In at least some cases, because acrylic requires less refractive and diffractive power than polycarbonate for the same focal length f as revealed by equations (5a), (5b), (6a), (6b) above, it may be advantageous for the hybrid lens

to be constructed of acrylic material instead of polycarbonate material.

FIG. 5B shows a lens 30 that is another embodiment of the hybrid lens, which embodiment includes an aspherical mold that is pressed from a drop of polymer to form an axicon 32 on a substantially spherical surface 34 of the lens. The lens 30 also includes a DOE 36 formed in another surface 38 of the lens. FIG. 5A provides a conceptual illustration of lens 30.

The DOE 36 may have eight phase levels 40a-h as illustrated by FIG. 6 which for clarity shows DOE 36 in a flat profile, not in the actual convex profile provided in accordance with the athermal aspect of the hybrid lens as described above.

The axicon enhances the ability of the hybrid lens to focus laser beams to achieve elongated profiles advantageous for bar-code scanning, as described below.

FIG. 7 shows a lens 42 that is another embodiment of the hybrid lens, which embodiment has an aspherical surface 34′ that has the optical properties of surface 34 combined with axicon 32. Thus lens 42 performs similarly to lens 30 but is a single piece and therefore may be less expensive to manufacture.

Lenses 30 and 42 may be made of polycarbonate which has properties described above.

A lens-axicon combination may be particularly useful for extending the working range (e.g., by 50-100%) of a CCD-based bar code scanner. In the combination, the axicon operates as a phase correction element to allow the scanner to resolve an out-of-focus bar code that the scanner could not resolve by relying on the lens alone.

FIG. 8 illustrates lens 44 and axicon 46 which together are an example combination 48 of the lens-axicon

combination. Combination 48 has an aperture 50 that has a diameter l and is a distance a from a CCD imager 52 of a bar code scanner, a distance b from an in-focus point 54, and a distance z from a barcode-bearing surface 58 at a surface point 56. The lens 44 may be a doublet, a Cook triplet anastigmat or a symmetric double Gaussian, and provides optical power to bend incident light toward the imager 42. By providing a longitudinal spherical aberration, the axicon 46 effectively elongates the focal depth of the lens 44 by contributing phase correction when the surface 58 is not at the in-focus point 54. The axicon 46 has an axicon induced phase coefficient α.

Equation (7) describes an MTF value as a function of spatial frequency v (e.g., of a bar code symbol) for a lens having an axicon that includes a circular pupil of diameter l, and has polar coordinate values ρ and θ with an origin at the pupil's center, and a normalized radial coordination value v (i.e., half of the product of ρ and diameter l), where λ represents the wavelength and k represents the wave number (i.e., 2π divided by the wavelength λ).

(7)

$$MTF(v)=\frac{4}{\pi}\int_{\theta=0}^{\theta=\pi/2}d\theta\int_{r=0}^{r=-v\cos\theta+\sqrt{1-v^2\sin^2\theta}}\cos\left\{k\left[4vr\cos\theta+\alpha\left(\sqrt{v^2-2vr\cos\theta+r^2}-\sqrt{v^2+2vr\cos\theta+r^2}\right)\right]\right\}rdr$$

FIGs. 9A and 9B show modulation transfer function ("MTF") curves MTF1a, MTF2a, MTF3a and MTF1b, MTF2b, MTF3b, respectively, each of which describes the sharpness of an image of a bar code symbol as a function of the distance z, for a particular value (i.e., 0, -0.003, or -0.001) for the axicon induced phase coefficient α and a particular spatial wavelength (i.e., 10 mil or 20 mil) of the bar code symbol.

A high MTF value represents a substantially in-focus image at the imager, and an MTF value near zero represents an image that is almost completely out of focus. In general, data can derived from an image of a bar code symbol more accurately if the image is sharper.

As shown in FIG. 9A, where the spatial wavelength is 10 mil and the axicon induced phase coefficient α has a value of 0 (i.e., where there is effectively no axicon), curve MTF1a shows that the MTF value peaks at about 0.75 at a z distance of about 5 inches, and remains below 0.2 for any z distance greater than 11 inches. By contrast, as shown by curve MTF2a, the use of an axicon having a value of -0.003 for the axicon induced phase coefficient α changes the optical characteristics of the lens-axicon combination so that the MTF value peaks at about 0.5 at a z distance of about 9.5 inches, and remains above 0.2 in a z distance range from about 4 inches to about 16 inches. Thus, for example, if data can be derived accurately from a bar code symbol image that has a sharpness corresponding to an MTF value of 0.2 or greater, for a bar code symbol having a spatial wavelength of 10 mil the axicon allows data to be derived from a distance of up to about 16 inches, which is about 5 inches further than data can be derived without the axicon.

FIGs. 9A, 10A-10B, and 11A-11B illustrate MTF curves MTF1b-MTF3f for other values for the axicon induced phase coefficient α. FIGs. 12 and 13 show other MTF curves that describe the sharpness of an image of a bar code symbol as a function of a normalized spatial wavelength v for several values for the axicon induced phase coefficient α and several values for focusing error w.

Other embodiments are within the scope of the following claims. For example, each lens may be formed from

separate pieces (e.g., refractive lens and DOE pieces) or may be formed as a single unit. Other types of plastic may be used. In each lens, refractive or diffractive power may be distributed in any way that renders the lens substantially athermalized.

What is claimed is:

1. A plastic lens, comprising:

refractive and diffractive optical apparatus configured to produce optothermal changes substantially canceling each other over a predetermined working temperature range to render the plastic lens substantially athermalized over the range.

2. The lens of claim 1, comprising

a refractive surface and a diffractive optical element, wherein optothermal changes due to the refractive surface counter optothermal changes due to the diffractive optical element.

3. The lens of claim 1, wherein the optothermal changes canceling each other include changes affecting the focal length of the lens.

4. The lens of claim 1, comprising polycarbonate.

5. The lens of claim 1, comprising acrylic.

6. The lens of claim 1, wherein the lens has a net positive power.

7. The lens of claim 1, wherein an optothermal expansion coefficient of the refractive optical apparatus is higher than an optothermal expansion coefficient of the diffractive optical apparatus.

8. The lens of claim 1, comprising a diffractive

optical element that is substantially smaller than the lens.

9. The lens of claim 1, wherein a first surface of the lens provides substantially all of the negative power of the lens, and a second surface of the lens provides substantially all of the positive power of the lens.

10. The lens of claim 1, wherein a surface of the lens provides substantially all of the negative power of the lens and substantially all of the positive power of the lens.

11. The lens of claim 1, wherein the diffractive optical apparatus includes a diffractive optical element that is substantially spherical in average.

12. The lens of claim 1, wherein a surface of the lens is substantially flat.

13. The lens of claim 1, wherein the refractive optical apparatus is divided unevenly between first and second surfaces of the lens.

14. The lens of claim 1, wherein substantially all of the diffractive optical apparatus is disposed on one surface of the lens.

15. The lens of claim 1, wherein the diffractive optical apparatus is divided substantially evenly between first and second surfaces of the lens.

16. The lens of claim 1, wherein the lens includes an axicon.

17. The lens of claim 16, wherein the axicon includes a polymer.

18. The lens of claim 16, wherein the axicon is disposed at a substantially spherical surface of the lens.

19. The lens of claim 16, wherein a diffractive optical element and the axicon are disposed at different surfaces of the lens.

20. The lens of claim 16, comprising a diffractive optical element that includes at least eight phase levels.

21. The lens of claim 16, comprising a diffractive optical element that includes fewer than nine phase levels.

22. The lens of claim 16, wherein the axicon is affixed to a surface of the lens.

23. The lens of claim 16, wherein the lens has an aspherical surface having the optical properties of a combination of a spherical surface with the axicon.

24. The lens of claim 16, wherein the lens includes a doublet.

25. The lens of claim 16, wherein the lens includes a Cook triplet anastigmat.

26. The lens of claim 16, wherein the lens includes a symmetric double Gaussian.

27. The lens of claim 16, wherein the MTF of the lens is higher with the axicon than without the axicon for bar code symbols having spatial wavelengths of 10-20 mils, inclusive.

28. The lens of claim 16, wherein the MTF of the lens is at least 0.2 for a 10 mil bar code symbol that is from about 4 to about 16 inches away from the lens.

ATHERMALIZED PLASTIC LENS

Abstract of the Disclosure

A plastic lens includes refractive and diffractive optical apparatus configured to produce optothermal changes substantially canceling each other over a predetermined working temperature range to render the plastic lens substantially athermalized over the range.

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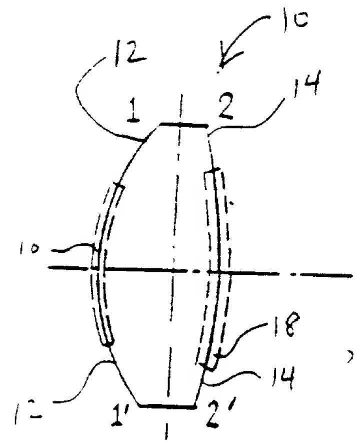

FIG. 1

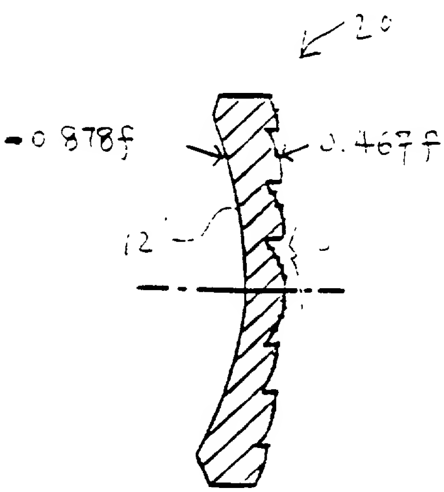

FIG. 2A

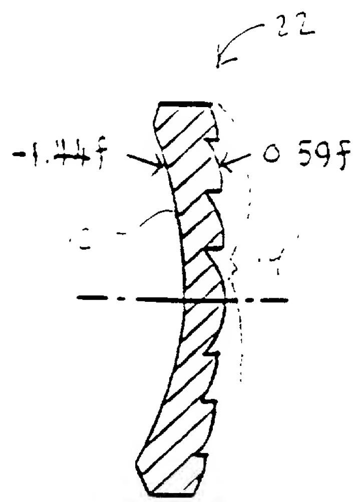

FIG. 2B

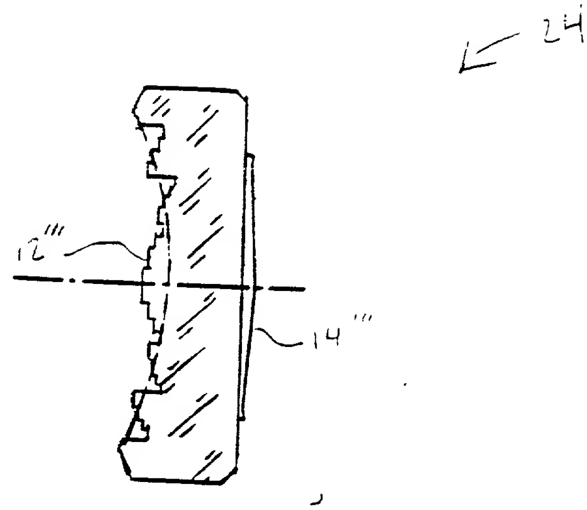

FIG. 3

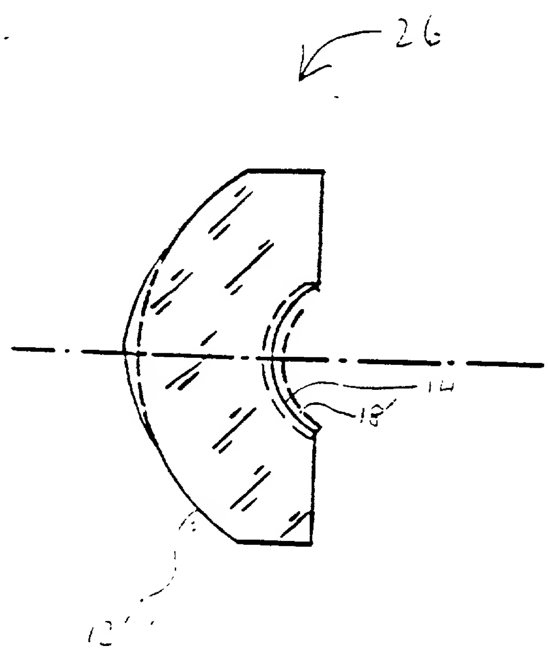

FIG. 4

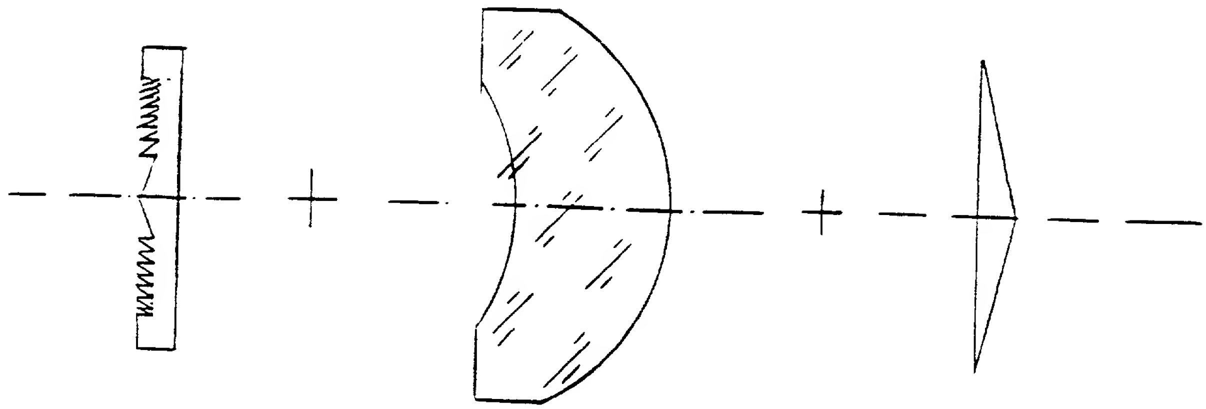

FIG. 5A

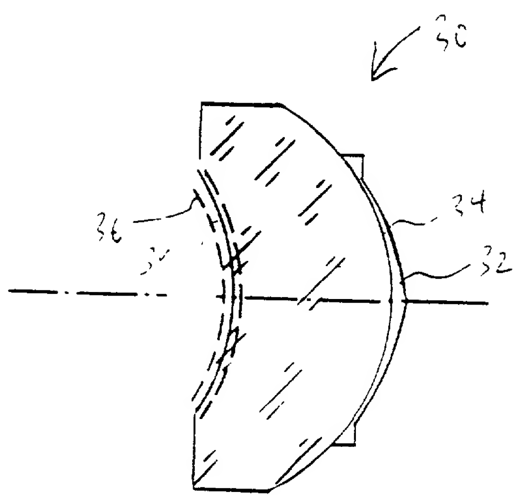

FIG 5B

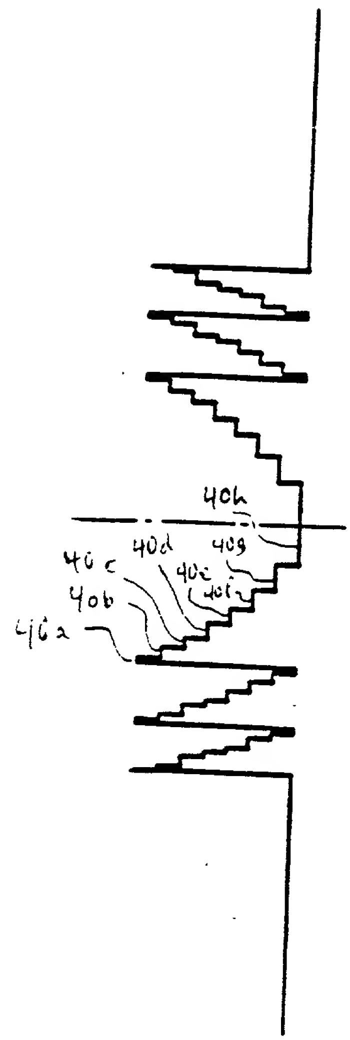

FIG 6

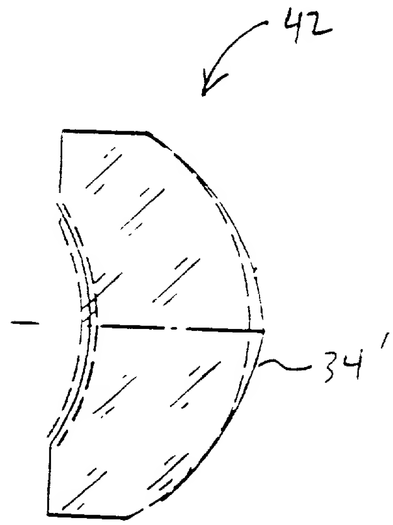

FIG. 7

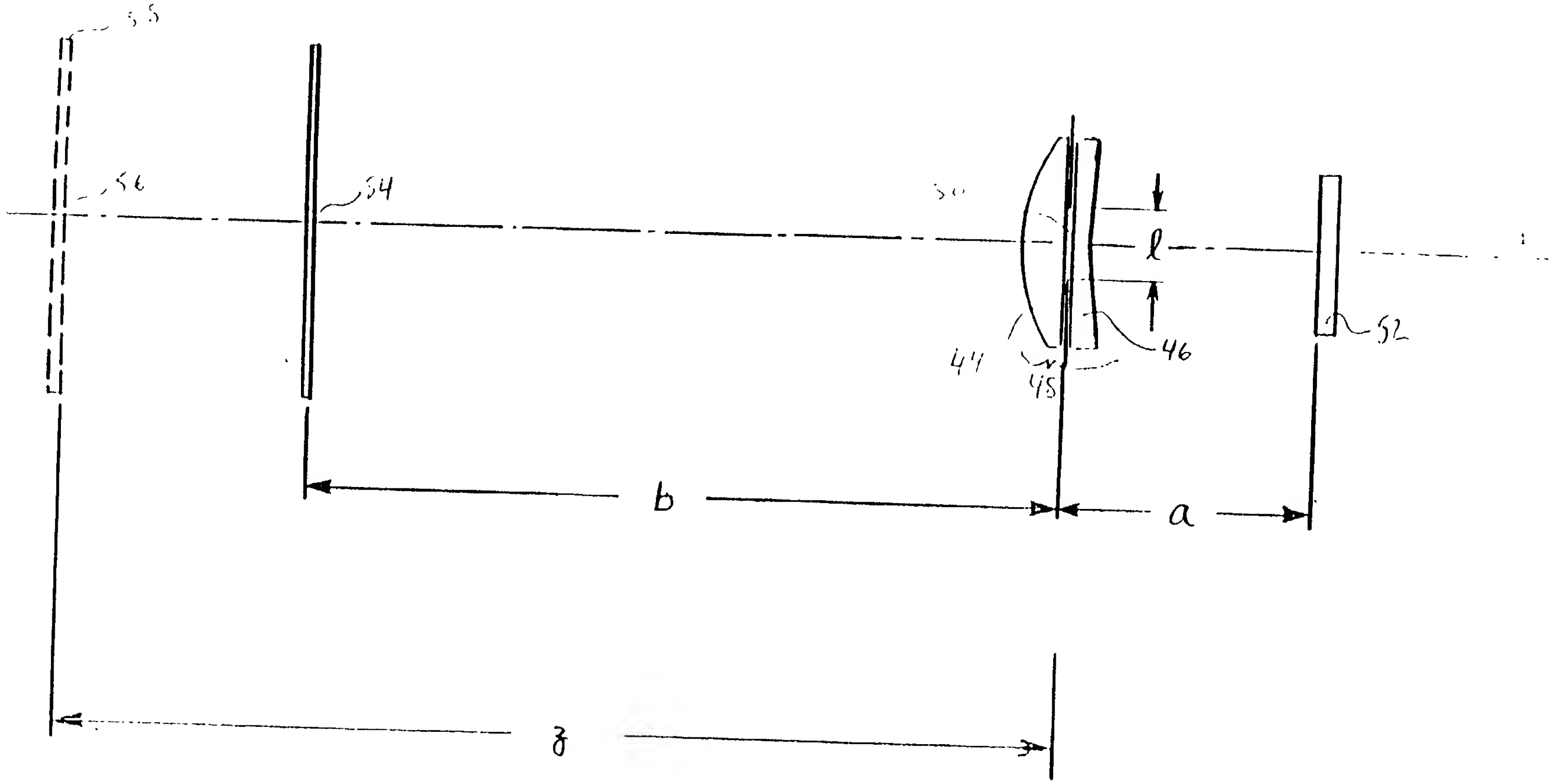

FIG. 8

CCD

10mil Symbols

z (inch)	MTF1a	MTF2a	MTF3a
2 662	0.4	0 15	-0.2
3 669	0 59	0 25	-0 2
5 264	0.72	0 42	-0.18
6 725	0 64	0.44	-0.1
9 309	0 35	0.5	0 01
11 523	0 19	0.4	0 05
15 118	0 08	0 25	0.05
21 974	0 03	0 04	0 07
24 618	0	0	0
	=0	α=-.0003	α=-.001

20mil Symbols

z (inch)	MTF1b	MTF2b	MTF3b
2 662	0 75	0.65	0.3
3 669	0 8	0 7	0.25
5 264	0 85	0.72	0.15
6 725	0 82	0 75	0.08
9 309	0 65	0.74	-0 06
11 523	0 48	0.7	-0 06
15 118	0 22	0 56	-0 03
21 974	0 03	0.35	0.06
40 208	0 05	0.02	0
49 236	0	0	0
	α =0	α=-.0003	α=-.001

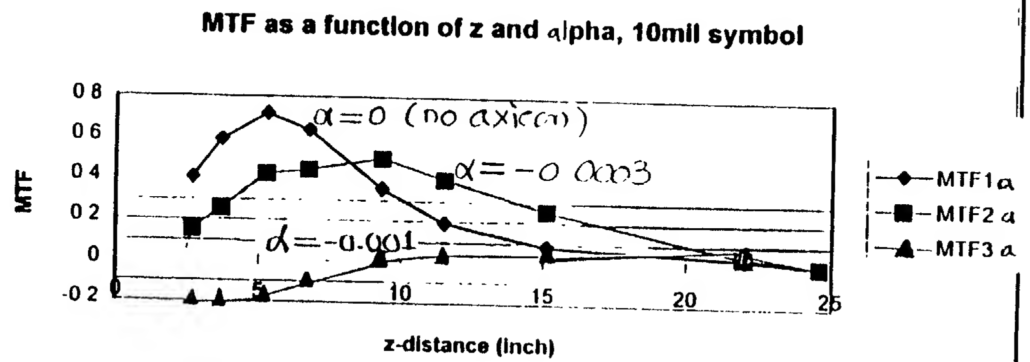

FIG 9A

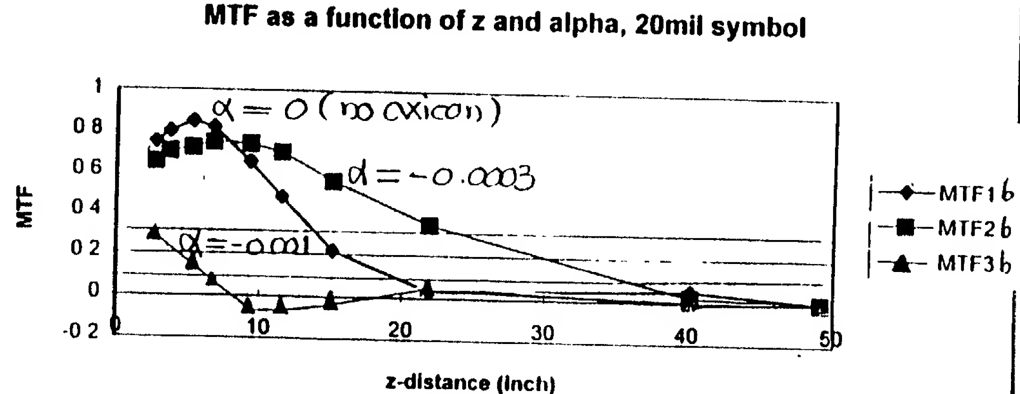

FIG. 9B

CCD

10mil Symbols

z (inch)	MTF1c	MTF2c	MTF3c
2.662	0.4	0.65	0.77
3.669	0.59	0.78	0.33
5.264	0.72	0.62	-0.18
6.725	0.64	0.27	0
9.309	0.35	-0.01	0.04
11.523	0.19	-0.03	0
15.118	0.08	-0.01	0.02
21.974	0.03	0.02	0.01
24.618	0	0	0
	$\alpha=0$	$\alpha=.0003$	$\alpha=.001$

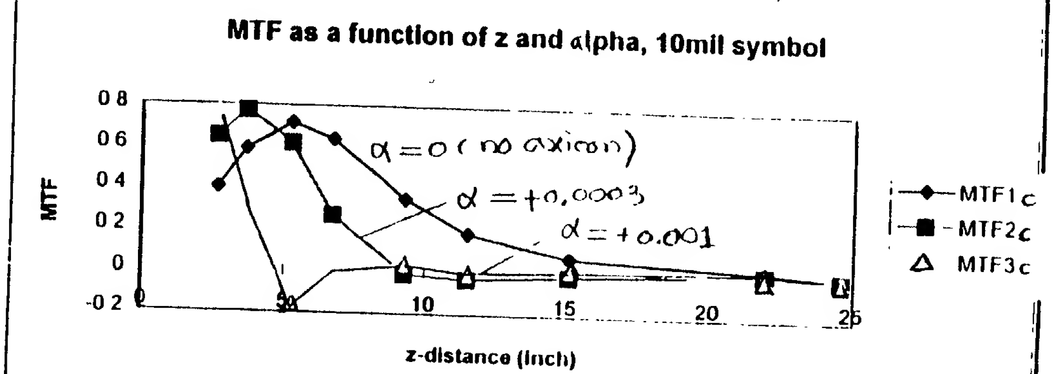

FIG. 10A

20mil Symbols

z (inch)	MTF1d	MTF2d	MTF3d
2.662	0.75	0.85	0.9
3.669	0.8	0.9	0.75
5.264	0.85	0.8	0.3
6.725	0.82	0.65	-0.05
9.309	0.65	0.28	-0.15
11.523	0.48	0.15	0.02
15.118	0.22	-0.1	0.08
21.974	0.03	-0.01	0
40.208	0.05	0.02	0
49.236	0	0	0
	$\alpha=0$	$\alpha=.0003$	$\alpha=.001$

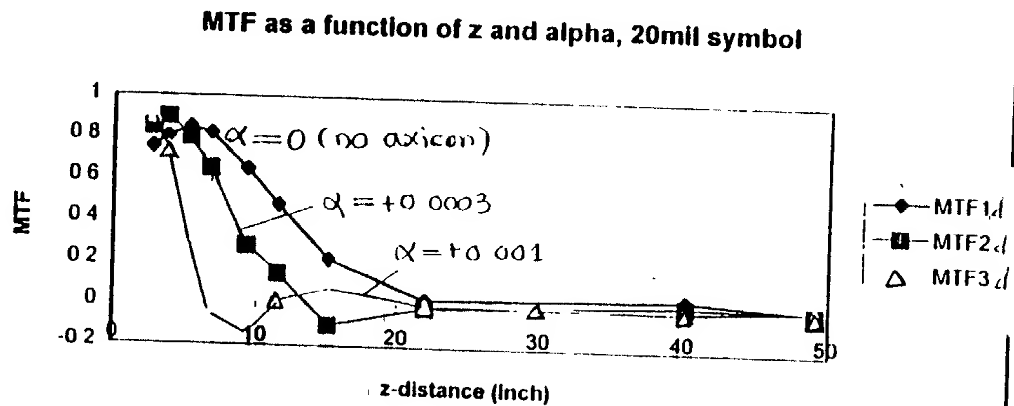

FIG. 10B

CCD

10mil Symbols

z (inch)	MTF1e	MTF2e	MTF3e
2 662	0 2	0.15	0.05
3 669	0 35	0 25	0 15
5 264	0 55	0.42	0.28
6 725	0 62	0.44	0.35
9 309	0 54	0.5	0.4
11 523	0.38	0 42	0 38
15 118	0.2	0 25	0 28
21 974	0 03	0 04	0.06
24 618	0	0	0
	α =-.0002	α =-.0003	α =-.0004

20mil Symbols

z (inch)	MTF1f	MTF2f	MTF3f
2 662	0 78	0.65	0.6
3 669	0.77	0.7	0 64
5 264	0 8	0 72	0.67
6 725	0 8	0 75	0 7
9 309	0 69	0 74	0 75
11 523	0 67	0.7	0 67
15 118	0 66	0 56	0 58
21 974	0 27	0 35	0 43
40 208	0 07	0 08	0.09
49 236	0	0	0
	α =-.0002	α =-.0003	α =-.0004

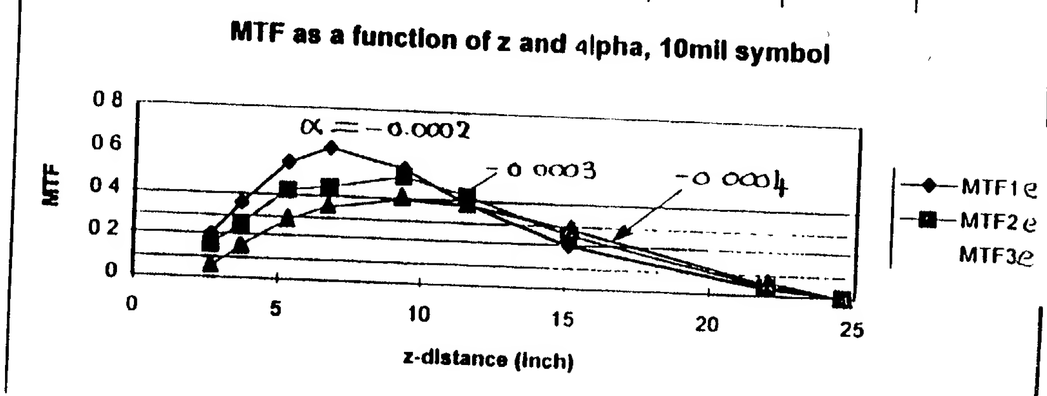

FIG. 11A

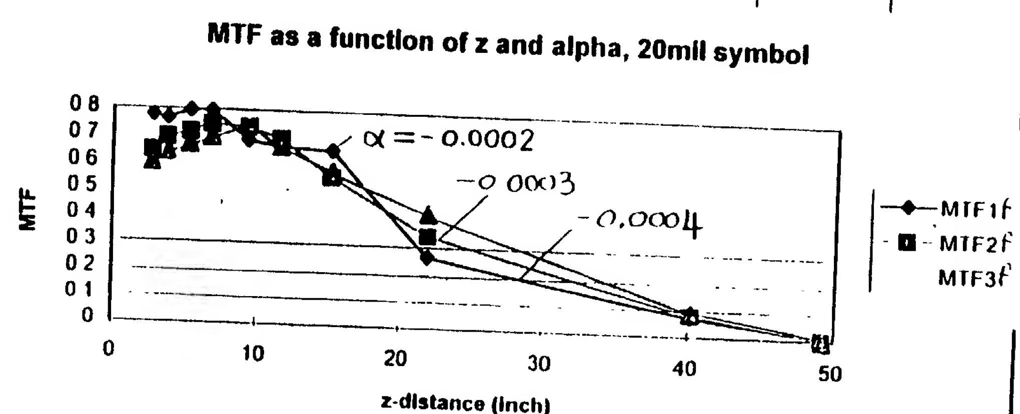

FIG. 11B

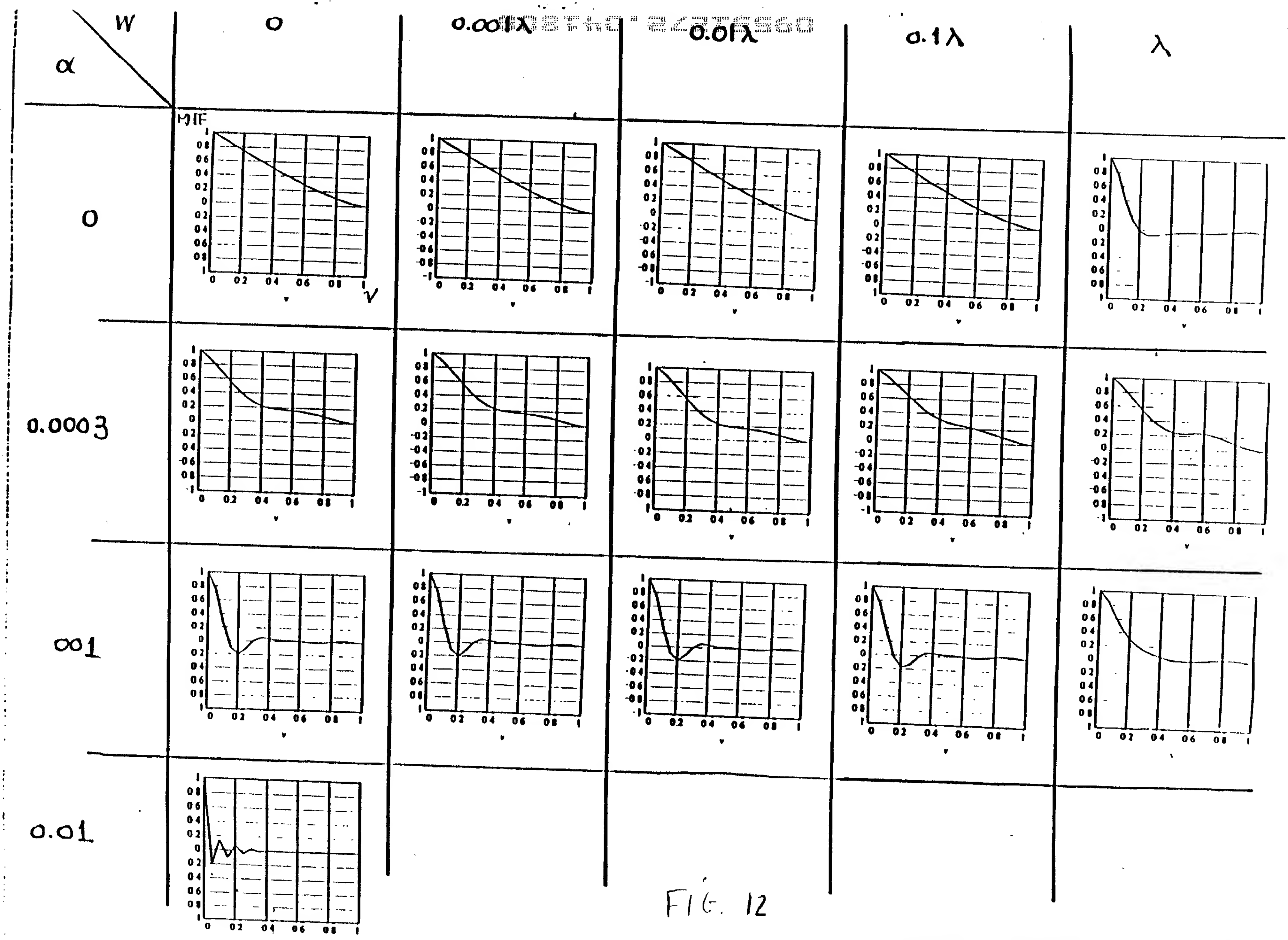

FIG. 12

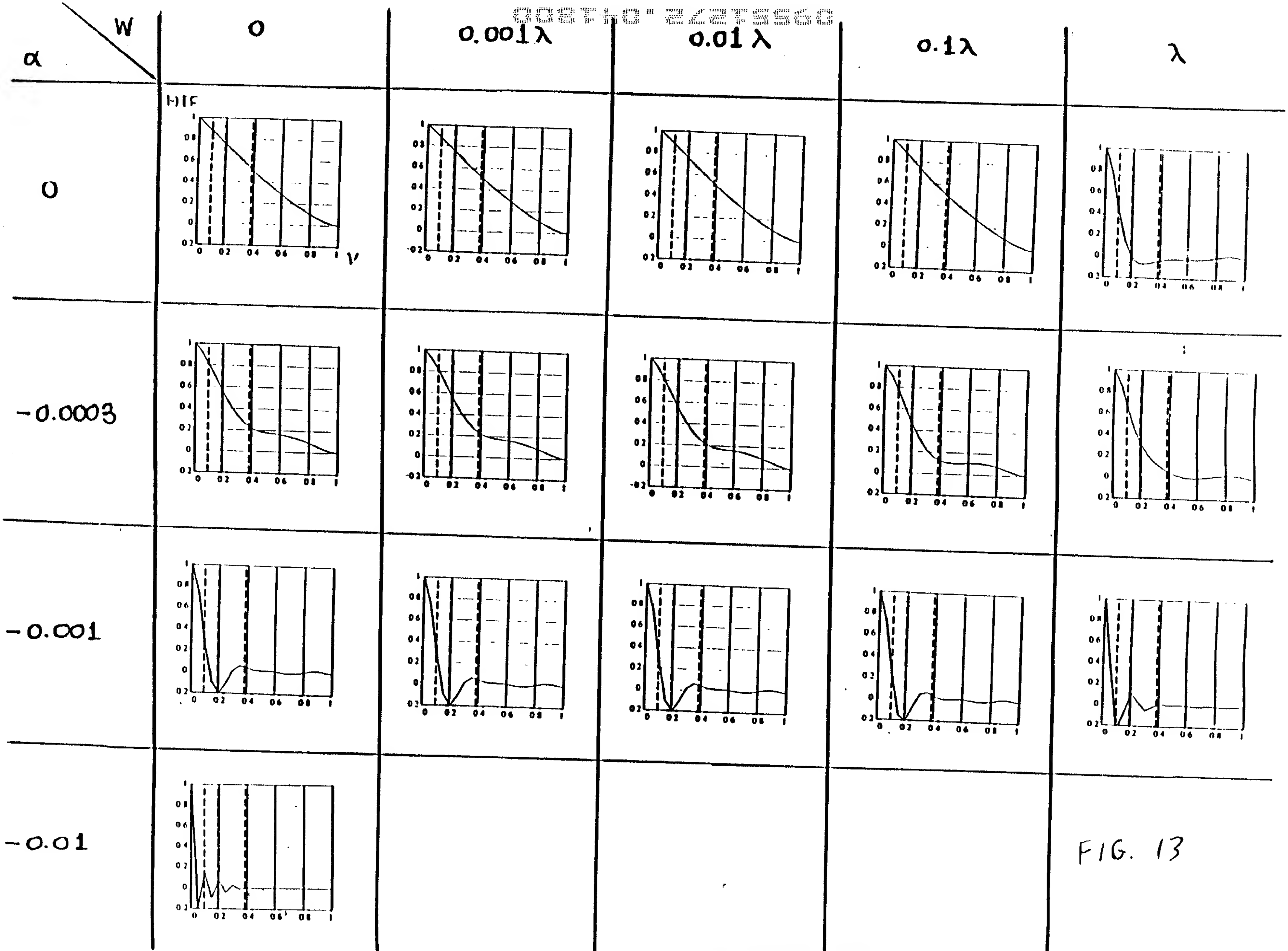

FIG. 13

PATENT
ATTORNEY DOCKET NO: 04873/065001

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ATHERMALIZED PLASTIC LENS, the specification of which

- ■ is attached hereto.
- ☐ was filed on ______________ as Application Serial No. ______________ and was amended on ______________.
- ☐ was described and claimed in PCT International Application No. ______________ filed on ______________ and as amended under PCT Article 19 on ______________.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. SERIAL NO.	FILING DATE	STATUS		
08/953,543	10/20/97	■ Pending	☐ Issued	☐ Abandoned
08/624,935	03/22/96	■ Pending	☐ Issued	☐ Abandoned
08/173,255	12/27/93	☐ Pending	☐ Issued	■ Abandoned
07/860,390	03/30/92	☐ Pending	☐ Issued	■ Abandoned

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: G. Roger Lee, Reg. No. 28,963 and Daniel R. McGlynn, Reg. No. 26,570

Address all telephone calls to G. Roger Lee at telephone number 617/542-5070.

Address all correspondence to G. Roger Lee, Esq., Fish & Richardson P.C., 225 Franklin Street, Boston, MA 02110-2804.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

COMBINED DECLARATION AND POWER OF ATTORNEY CONTINUED

Full Name of Inventor: Yajun Li

Inventor's Signature: ______________________ Date: ______________

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Citizen of: United States

Post Office Address: same as above

Full Name of Inventor: Vladimir Gurevich

Inventor's Signature: ______________________ Date: ______________

Residence Address: 500 Peconic Street, Apt. 14A, Ronkonkoma, NY 11779

Citizen of: Russia

Post Office Address: same as above

Full Name of Inventor: Mark Krichever

Inventor's Signature: ______________________ Date: ______________

Residence Address: 26 Carldon Lane, Hauppague, NY 11788

Citizen of: United States

Post Office Address: same as above

Full Name of Inventor: Edward D. Barkan

Inventor's Signature: ______________________ Date: ______________

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Citizen of: United States

Post Office Address: same as above

COMBINED DECLARATION AND POWER OF ATTORNEY CONTINUED

Full Name of Inventor: Miklos Stern

Inventor's Signature: ______________________ Date: ______________

Residence Address: 138-31 Jewel Avenue, Apt. D, Flushing, NY 11367

Citizen of: United States

Post Office Address: same as above

D E C L A R A T I O N

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe the below named inventors are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled **"ATHERMALIZED PLASTIC LENS "** the specification of which:

☐ is attached hereto.
☐ was filed on ________________ as Application Serial No. ________________.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims.

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability of the subject matter claimed in this application as "materiality" is defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

(Number)	(Country)	(Date Filed)	Priority Claimed Yes/No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States Application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose all information known to me to be material to patentability of the subject matter claimed in this application, as "materiality" is defined in Title 37, Code of Federal Regulations, § 156, which become available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Daniel R. McGlynn, Reg. No. 26,570

I direct that all correspondence and telephone calls be addressed to

Daniel R. McGlynn
Symbol Technologies, Inc.
One Symbol Plaza
Holtsville, NY 11742
(516) 738-4627.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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(First) (Initial) (Last)

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Date: 11.24.98 Country of Citizenship: U. S. A.

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(First) (Initial) (Last)

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Inventor's Signature: Miklos Stern

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